# SECTION 1C

# NAVAL ARCHITECTURE



## 1C.1 REFERENCES

(1C*A*) 46CFR Sub-chapter S

(1C*B*) WSDOT Terminal Design Parameters

(1C*C*) WSF Standard Truck and Car Weights and Standard Loading Conditions, Rev B (October, 1993)

## 1C.2 INTRODUCTION

This Section contains the general requirements for Vessel load carrying capacity, weight control, intact stability and damaged stability.

***For WSF Fleet-wide Standardization purposes, End No. 1 of the Vessel shall always be considered the bow, and this designation shall delineate port and starboard, fore and aft wherever they are addressed in the Technical Specification.***

## 1C.3 GENERAL

For WSF Fleet-wide Standardization purposes, hydrostatic and stability calculations shall be conducted utilizing "General HydroStatics" (GHS), software provided by CREATIVE SYSTEMS, INC., P.O. Box 1910, Port Townsend, WA. 98368. The final hydrostatics model based on the As-Built Lines Plan, including tanks with sounding tubes compartments, deck edge definition and sail area, shall be delivered to WSF. The model shall be similar to the existing fleet models in extent, format and data entry. Upon request, WSF will provide a representative sample for information.

## 1C.4 LOADS

The Contractor shall make the following assumptions in developing the Vessel's load conditions:

A. Vehicle Deck Loads

In accordance with WSF policy, vehicle quantities are described in linear feet (LF) of lane and unit weights are described in pounds per linear feet of lane. In general, an auto requires 18'-6" feet (linear, see the *Vehicle Decks Layout* Subsection in Section 1B of the Technical Specification) to park and a highway truck requires 43 feet. The Vessel is required to transport 144 autos **or** 21 highway trucks and 97 autos.

In accordance with WSF policy, Reference (1C*C*) is used for structural design and limiting stability conditions. However, these weights are intended to provide "**worst case**" loads and are, therefore, overly conservative for normal operations. Therefore, "Estimated (average) Vehicle Weights" are to be assumed for the "**design operating**" and "**mid-service-life**" condition.

1. Design vehicle loads for scantling and "**worst case**" stability conditions:

a. Highway Trucks 813 lbs/ft
b. Light Trucks 300 lbs/ft
c. Autos 200 lbs/ft

The "**worst case**" stability loading will assume:

a. 1,006 lane feet of Highway Trucks on the Lower Vehicle Deck (LVD) (Tunnel)

b. 256 lane feet of Light Trucks on the LVD

c. 78 lane feet of Light Trucks on the ramps to the Upper Vehicle Deck (UVD)

d. 237 lane feet of Light Trucks on the UVD

e. 475 lane feet of Autos on the LVD

f. 156 lane feet of Autos on the ramps to the UVD

g. 474 lane feet of Autos on the UVD

2. Design vehicle loads for "**design operating**" stability condition:

a. Highway Trucks 450 lbs/ft
b. Light Trucks 160 lbs/ft
c. Autos 160 lbs/ft

These loads are to be distributed in the same location and lane-feet specified in the "**worst case**" condition above.

B. Passenger and Crew Loads

1. Design Passenger loading for "**worst case**" stability condition is to be as follows:

1,500 Passengers at 190 lbs/Passenger and 20 Crew at 330 lbs/Crew assumed to be located on the uppermost deck accessible to Passengers (Sun Deck).

2. Design Passenger loading for "**design operating**" condition is to be as follows:

750 Passengers, 50-percent (50%) at 190 lbs/Passenger and 20 Crew at 330 lbs/Crew assumed to be located on the uppermost deck accessible to Passengers (Sun Deck).

C. Other Loads

| | | **"worst case"** | "**design operating**" |
|---|---|---|---|
| 1. | Stores and Provisions | 22 LT | 22 LT |
| 2. | Fuel Oil | 230 LT | 177 LT |
| 3. | Potable Water | 70 LT | 35 LT |
| 4. | Sewage | 0 LT | 35 LT |
| 5. | Misc. Liquids | 36 LT | 36 LT |

**Note:** See Section 78 for required tank capacities and locations.

D. Load Margins

The following load margins are to be applied to the operating conditions:

1. Load Design Margin

   3-percent (3%) of the weight of stores, provisions and liquids in all load conditions applied at amidships and six (6) feet above the LVD.

2. Service Life Margin

   A total of 450 LT is to be assumed for a Service Life Margin. This is to be applied at amidships and 6 feet above the LVD. In the "**mid-service-life**" condition 50-percent (50%) of the Service Life Margin, 225 LT, is to be applied at the same longitudinal and vertical location.

Freeboard to the Lower Vehicle Deck is limited to a maximum of ten feet - six inches (10'-6") measured from the highest part of the deck. The Vessel shall be able to obtain and maintain a freeboard of no more than ten feet – six inches (10'-6") in all conditions including burned-out.

The Lower Vehicle Deck shall have a minimum freeboard of five feet – six inches (5'-6") measured from the highest part of the deck in the maximum load condition.

The Contractor shall design the Vessel such that trim can be maintained in a range between zero (0) and 3 feet - 6 inches (3'-6") by the bow or stern in all load conditions while not exceeding a 18 feet - 0 inches (18'-0") navigation draft, and while maintaining propeller tip submergence of at least 2 feet - 6 inches (2'-6").

## 1C.5 WEIGHT AND CENTER OF GRAVITY CONTROL

The Contractor is wholly responsible for achieving the lightship weight specified in the Proposal Preliminary Weight Estimate of the WSF Approved Phase II Technical Proposal as updated in the WSF Approved Phase III Detail Design Control Weight Estimate, and for meeting all stability requirements of Reference (1C*A*). Weight and center of gravity estimates made during the Phase II Technical Proposal stage of Work shall be of sufficient detail to substantiate that the design makes adequate provision for the Passengers, Crew, loads, cargo, and equipment that the Vessel must transport.

### 1C.5.1 Proposed Preliminary Weight Estimate and Stability Analysis

Within 120 days after signing the "Notice to Proceed" (NTP) for Phase II Technical Proposal, the Contractor shall prepare and submit to the WSF Representative for acceptance, an independently prepared estimate of light ship weight and center of gravity (VCG and LCG) as well as Intact and Damaged Stability Analyses demonstrating compliance with Authoritative Agencies and WSF Load and Margin requirement. Acceptance shall be by mutual agreement between the Contractor and WSF on values for light ship weight and center of gravity. WSF and Contractor shall work to reach mutual agreement within two (2) weeks. The Proposed Preliminary Weight Estimate shall be updated throughout the Phase II Technical Proposal stage of Work and included in the Phase II Technical Proposal submittal.

**NOTE:** WSF acceptance of the Contractor's Proposed Preliminary Weight Estimate **in no way** alleviates the Contractor's responsibility for obtaining USCG approval of Vessel's stability.

### 1C.5.2 Weight Control Plan

The Contractor shall also prepare a written program and plan outlining the procedures that shall be followed to ensure that the Vessel's weight is controlled and shall be submitted with the Phase II Technical Proposal. The Weight Control Plan shall show how an accurate status of the weight condition of the Vessel during design and construction shall be maintained so that the Vessel's Weight and center of gravity can be shown to be consistent with the required

displacement, stability and performance. The Weight Control Plan shall include as a minimum the technical aspects of the following:

1. Where emphasis on weight control is to be applied (establish budgets for weight groups).

2. Method to be used in adjusting the builders margin for weight and moment.

3. Briefing schedule and Report due dates.

4. Tolerances and methods of weighing materials. Verify vendor weights; weigh items in excess of twenty (20) pounds; randomly select stock material (such as piping or insulation) to establish accurate unit weights; and weigh batches of such things as underlayment prior to application.

5. The detail to which calculations shall be made.

6. Management and technical authority of the Weight Control Coordinator.

7. How weight conditions shall be publicized.

8. Method and to what degree weight control shall be required of vendors.

9. Action that shall be taken when weight and moment trends show that the estimated values could be exceeded if corrective action is not taken. Such action may include:

    a. Re-engineering the effected weight group.

    b. Transfer of weight margin from another group that has excess margin.

    c. Notify the WSF Representative of the negative trend and proposed action to correct it.

    d. Incorporate the proposed action into the design and construction of the Vessel.

## 1C.6 WEIGHT AND CENTER OF GRAVITY ESTIMATE

Within 20 days of “Notice to Proceed” with Phase III Detail Design and Construction, a detailed Contract Weight and Center of Gravity Estimate shall be provided for approval, formatted according to MARAD Section. This mutually agreed and approved document

("R0") will provide a baseline for tracking weight changes throughout the construction process.

By the 10th day of each month, commencing sixty (60) days after "Notice to Proceed", the Contractor shall report the updated estimate of light ship weight and center of gravity. Approval shall be by mutual agreement between the Contractor and the WSF Representative on values for light ship weight and center of gravity (VCG and LCG). WSF and the Contractor shall work to reach mutual agreement within two (2) weeks. The monthly report shall begin with an executive summary that presents the weight history in a timeline format and highlight deviations from expected trends. Similar summary graphs for each technical specialty shall be created for review. Where margins are being consumed faster than predicted, publish explanations and methods to correct the trend. Summaries of weights by group shall be attached for more detailed information. Loft generated weight reports and actual structural unit weight data shall be required to be submitted.

Prior to delivery, the Contractor shall be responsible to obtain the approved weight and center of gravity characteristics, adjusted for any authorized changes in construction, in the completed Vessel.

For any construction changes that may affect the approved light ship weight or center of gravity, the Contractor shall submit estimates of changes to the light ship weight and center of gravity and obtain written approval of the changes, prior to proceeding with the changes.

The Contractor shall make every effort to eliminate unnecessary weight by sniping outstanding flanges, burning lightening holes, etc., and by using only the lightest material consistent with the basic design.

Prior to delivery of the Vessel but after the inclining experiment, a "Final As-Built" weight report shall be submitted with weights, levers and moments listed by weight group at light ship and full load. The report shall include the final draft, list and trim.

The weight control program for subsequent Vessels shall consist of quarterly reports of deviations in design or construction and a final report.

During the Phase III Detail Design and Construction stage of Work, the weight and center of gravity estimates shall be based on the means and methods described above. The Vessel's weight and center of gravity shall be monitored and calculated as it is designed and constructed.

Any adverse trends that would affect the design service life, range, operations or deadweight capacity shall be identified by the Contractor and corrected with approval by the WSF Representative.

## 1C.7 INTACT STABILITY

The Vessel shall have sufficient intact stability to comply with applicable regulations of the USCG in all operating conditions and at all Vessel life stages from delivery to end of service life.

The following requirements shall be met in the design of the Vessel and its systems:

A. Fixed ballast shall not be used in the design process to satisfy stability requirements.

B. The use of lead or liquid ballast to satisfy stability requirements is **unacceptable**.

C. Free surface effects in accordance with the Authoritative Agency requirements and operating practices shall be accommodated.

D. The operating and loading practices of the fleet shall be accommodated. For example, the Vessels take on partial loads as far forward as space permits in order to facilitate loading at the next port.

## 1C.8 STABILITY AND SUBDIVISION

Within 120 days after Contract Award, the Contractor shall submit to the WSF Representative for approval an independently prepared stability assessment indicating how the Vessel will meet the requirements of 46 CFR Sub-chapter S, upon completion.

Update the monthly estimate of light ship weight and center of gravity to reflect preliminary inclining experiment results.

If problems are apparent, prepare a corrective action plan for approval by the WSF Representative. After WSF approval of the corrective action plan, implement the corrective action plan and take all actions necessary, as approved by the WSF Representative, to meet 46 CFR Sub-chapter S requirements with the lightship weight requirement implied by the *LOADS* Subsection in this Section of the Technical Specification.

Upon completion of the Vessel, the Contractor shall incline the Vessel and determine its center of gravity (VCG and LCG) as required by the USCG and Section 101 of the Technical Specification. The Contractor shall provide WSF with copies of the USCG approved

Stability Assessment Report, and Simplified Stability Letter, in accordance with Section 100 of the Technical Specification.

In the event that the Stability Test required by Section 101 of the Technical Specification, shows inaccuracies or errors in the design and/or weight control process and proves insufficient stability or the existence of permanent list greater than ¼ degree port or starboard, or permanent trim of more than six (6) inches toward either End, provide sufficient fixed ballast, preferably located in the voids and/or sponson areas, for the Vessel to meet the criteria of 46 CFR Sub-chapter S and the freeboard requirements of the *LOADS* Subsection in this Section of the Technical Specification, or to remove any excess permanent list or trim. ***The weight of ballast added shall be kept to the absolute minimum required to ensure that the Vessel meets the stability requirements of the Authoritative Agencies*** or to remove excess permanent list or trim.

Ballast shall be of the steel bar type and not installed until the surfaces on which it will be placed have been cleaned and preserved as required in Section 14 of the Technical Specification. All ballast shall be sized to a maximum of fifty-five pounds (55 lbs.), so as to be readily handled by one person. Ballast that may be required shall be selected, with WSF approval, and installed in accordance with the provisions of USCG NVIC 5-82, *Guidelines for the Installation of Special Fixed Ballast Materials*. Ballast shall not be installed until the surfaces on which it will be placed have been cleaned and preserved. Ballast shall sit on fire retardant, wood cribbing to prevent direct contact with hull plate. Ballast and cribbing shall be constrained to adjacent structure and installed in a manner that will prevent pockets or interfere with proper drainage of the spaces in which it is installed. Constraint shall be by a method that will permit relative easy removal of portions of the ballast material to permit periodic inspection of the underlying surface. All ballast shall be prepared and coated as set forth in the *Steel Bar Type Ballast* Subsection in Section 14 of the Technical Specification.

List and trim shall be determined with the Vessel in a partially loaded condition with a normal load of stores and spare parts, fuel and lubricating oil storage tanks 95-percent (95%) full, potable water, sewage holding, and oily water holding tanks ½ full. Passenger and Vehicle loading shall not be considered in determining the existence of permanent list or trim.

## 1C.9 LINES OF HULL FORM

The shape of the hull shall conform to the Phase II Technical Proposal and all lines shall be carefully and thoroughly faired by the Contractor. All templates, battens, etc., shall be prepared in such a manner that the completed Vessel will conform with the Contract Lines Plan's dimensions. Upon completion of the Vessel, the Contractor shall furnish As-Built computer mold loft off-sets in reproducible form for WSF's files.

In the event the Contractor elects to use computer fairing in lieu of the computer mold loft, the Contractor must first submit for approval to the WSF Representative a lines plan faired by the computer and drawn by a computer-actuated plotter at the ½ inch scale for half-breadth and shear plans and ¾ inch scale for body plan and with all waterline, buttock lines, diagonals, and sections as shown on FIGURE 1A-1, Lines Plan, as set forth in the *WSF OPTIONAL HULL FORM* Subsection in Section 1A of the Technical Specification. In addition, the Contractor shall provide the computer printout of offset data on stations on the Phase II Technical Proposal lines plan. The permitted fairing deviation is no more than 0.5 inches from the Phase II Technical Proposal lines plan and is to be measured in a plane normal to the slope of the lines at the offset. No Work shall proceed on the preparation of templates, development of numerically controlled tape, or the preparation of offsets on frame lines until this basic computer-developed lines plan has been reviewed by WSF for conformance to the Technical Specification.

The lines of the hull shall be carefully faired, adhering closely to the lines and offsets furnished in the Phase II Technical Proposal. If, in the course of fairing, any significant discrepancies in the offsets as given on the drawing are brought to light, this fact shall be called to the attention of the WSF Representative immediately for resolution at the Contractor's expense.

## 1C.10 ADMEASUREMENT

The Contractor shall arrange with ABS to measure the Vessel for tonnage according to both the Standard System of Measurement in accordance with 46 CFR §69, and for International Tonnage Certificate (ITC). The Contractor shall furnish tonnage certificates, and mount one (1) copy of each under glass in a stainless steel frame in the No. 1 Pilothouse and shall furnish one (1) copy of each to the WSF Representative.

## 1C.11 PHASE II TECHNICAL PROPOSAL REQUIREMENTS

The following deliverables, in addition to other information required by Section 100 of the Technical Specification and the Authoritative Agencies, shall be submitted during the Phase II Technical Proposal stage of Work in accordance with the requirements in Section 100 of the Technical Specification:

A. Table of Hydrostatic Properties

B. Intact Stability Calculations

C. Damage Stability Calculations

D. Capacity Plan

E. Weight Control Plan

F. Proposal Weight Estimate, updated to level of design of the Technical Proposal

G. Creative Systems GHS Geometry file (including all compartments, tanks, sounding tubes, and sail area from Computer Mold Loft Offsets)

The ***Hull Lines Plan with Offsets*** shall depict all major hull appendages (e.g., rudders, shaft struts, bossings, and skeg), and include a listing of principal characteristics and a table of offsets.

The ***Capacity Plan*** shall include diesel oil, sewage, water and cargo (Passenger and Vehicle) capacities; centers-of-gravity; permissible deck loads; and deadweight scale.

The ***Weight Control Plan*** and format for the weight estimate shall be submitted for WSF Representative approval within thirty (30) days following "Notice to Proceed" with Phase II Technical Proposal. The first estimate shall be due three (3) months after "Notice to Proceed" with Phase II Technical Proposal, and an updated estimate shall be provided at least monthly thereafter until Operational Acceptance of the Vessel.

See Section 100 of the Technical Specification for additional requirements regarding technical documentation.

## 1C.12 PHASE III DETAIL DESIGN AND CONSTRUCTION REQUIREMENTS

The following deliverables, reports, booklets, and calculations, in addition to others required by Section 100 of the Technical Specification and the Authoritative Agencies shall be developed using the final As-Built geometry file and, shall be submitted during the Detail Design stage of Work in accordance with the requirements of Section 100 of the Technical Specification:

A. Tables of Hydrostatic Properties

B. Curves of Form

C. Inclining Experiment Report

D. Intact Stability Calculations

E. Damage Stability Calculations

F. Trim & Stability Booklet

G. Creative Systems GHS Geometry file and Hydrostatics Computer Model (Including all compartments, tanks, sounding tubes and sail area)

H. Weight Estimates

I. Capacity Plan

J. Tank Capacity and Sounding Tables with Calculations

K. Tonnage Calculations and/or Tonnage Plans

The ***Curves of Form*** shall include the following hydrostatic properties in tables and plotted as curves versus draft: Area of Waterplane, Tons Per Inch Immersion, Longitudinal Center of Floatation, Transverse Metacentric Radius, Longitudinal Metacentric Radius, Molded Displacement, Total Displacement, Longitudinal Center of Buoyancy, Vertical Center of Buoyancy, Change of Displacement with Trim and Moment to Change Trim. The drafts shall range from four (4) feet to full load, including allowance in full load draft for service weight growth margin.

The ***Inclining Experiment Report*** shall be provided to the WSF Representative within seven (7) days after the completion of the Inclining Experiment.

The ***Damage Stability Calculations*** shall be provided to the WSF Representative within thirty (30) days after the completion of the Inclining Experiment.

The format of the ***Trim and Stability Booklet***, required for the Phase III Detail Design, shall be submitted for WSF Representative approval at least ninety (90) days after Phase III Award of Contract date.

The ***Trim and Stability Booklet*** shall be prepared to obtain a simplified stability letter from the USCG which allows sailing without calculating stability for each voyage, but rather relates to vehicle capacities and quantities. The Booklet shall properly address the intact stability requirements delineated in the *WEIGHT AND CENTER OF GRAVITY ESTIMATE* Subsection in this Section of the Technical Specification. The ***Trim and Stability Booklet*** shall be provided to the WSF Representative within fourteen (14) days after the completion of the Inclining Experiment.

***Tank Capacity and Sounding Tables with Calculations*** shall be based on the assumption that the Vessel is on an even keel, with deductions made for all obstructions such as structure, piping and fixed ballast within the tanks. The Tables shall be provided in booklet form with 11 inch × 17 inch pages. The booklet shall consist of a title page, an index page, a summary page, pages tabulating capacities for each tank arranged for carrying liquids, and a listing of the locations and lengths of all sounding tubes, measured from striker plate to top

of tube. The summary page shall include a tabulation for each type of liquid, showing total capacity (in gallons) of individual tanks and total capacity for each type of liquid. For tanks fitted with sounding tubes, the sounding tables shall depict the quantity of liquid associated with the reading obtained from a sounding tape which is in contact with the striker plate and accounting for the slope and curvature of the sounding tube as installed. Capacity Tables shall list tank capacity in gallons for each inch of sounding and have the following format:

A. Vertical columns from left to right with heading reading "Sounding in Feet," and the remaining columns numbered "0" to "11", inclusive, and sub-headed "Sounding in Inches."

B. In the left-hand column, a tabulation listing from top to bottom, each foot of sounding from zero to maximum reading.

C. Capacities in gallons shall be entered in the proper spaces so that for any given foot and inches of sounding, the capacity can be obtained.

D. The following information shall be noted on each page:

1. Vessel name and Builder's Hull Number.
2. Tank name and location.
3. Type of liquid carried.
4. Sounding and capacity when the tank is full.
5. Sounding and capacity when the tank is 95-percent (95%) full (oil tanks only).
6. Amount of liquid remaining in each tank when the lowest point of suction has been reached.

A second booklet of tank capacity tables shall be provided for the design trim condition, if different from even keel.

See Section 100 of the Technical Specification for additional requirements regarding technical documentation.

The ***Tonnage Calculations and/or Tonnage Plans*** shall be prepared to obtain the required tonnage certificates. The calculations and plans shall be submitted to the USCG and the WSF Representative as early as practicable.

**(END OF SECTION)**